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Application of Lean Concepts in Building Construction

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Abstract— **The construction industry has demonstrated a decline in productivity when compared to other industries over the past twenty years. In order to overcome this defect in the construction industry, the lean concept has been introduced. Lean concepts have caused a revolution in manufacturing design, supply, and assembly. Applied to construction, lean concepts can change the way of work is done throughout the facility delivery process. The construction project where lean principle is applied to is defined by the term lean construction.Lean construction is a method of production aimed at reducing time, cost, materials and effort. It is about designing and building a solution that meets client needs and getting it right the first time. Improvement of processes and elimination of waste is fundamental to this. To achieve this, it is essential that we work closely with the client in order to deliver a product that meets their needs and requirements. Lean needs to focus on delivering value by addressing the lowest total cost as opposed to being driven by price. To do this, it is necessary to focus on processes that can be improved and remove all those elements that do not add value. In lean construction, owner, designers, contractors, and suppliers work together to produce a value-adding, efficient and maintainable facility.**

Index Terms— **Corrections, Likert scale, Over – Processing, Waiting.**

I. INTRODUCTION

For many years, the construction industry in India has suffered from its inability to deliver projects in time, within budget and within the quality demanded by the customer. Meeting customer requirements and increasing the efficiency of the project is of sublime importance in such an industry. Most of the Indian contractors are not well equipped to handle the growing demand and hence projects quite frequently run into time and cost overruns, disputes and compromising on the quality. Productivity helps construction industries to be competitive, to achieve goals and to meet the stakeholder and value propositions. Continuous innovation is a key prerequisite for remaining competitive in the current dynamic market place. Many construction industry sectors have been experiencing chronic problems such as poor management, inferior working conditions, and insufficient quality. Many researchers have identified these problems as factors that affect construction productivity and will affect a company's performance and the overall economy of the country.

Meanwhile, identification and evaluating factors affecting delays in construction industry have been done in the last decade; however, a deeper understanding is still needed to improve the labour productivity. There is reluctance in the Indian firms to change their mindset and their construction practices, in-spite of the increasing focus on the quality of projects; this is partly due to the lack of global participation in the Indian construction industry. To monitor the projects the firms still employ the traditional method of project monitoring which includes the earned value estimate of finding the schedule and cost variances.

A. Terms considered in questionnaire

1. Work Breakdown Structure
2. Critical Path Method
3. Look Ahead Plans
4. Constraint Analysis
5. Productivity
6. Value Stream Analysis (Mapping)
7. Last Planner System
8. Pull Approach
9. 5 – S System
10. First Run Study
11. Relational Contracting /Partnering
12. Integrated Project Delivery System
13. Root Cause Analysis
14. Delays

II. ANALYSIS AND RESULTS

The most delay causing wastes have been identified using a Likert scaling system (a weight of 1 for primary cause of waste, weight of 2 for secondary cause of waste and weight of 3 for tertiary cause of waste). The resulting pie chart is as follows:-

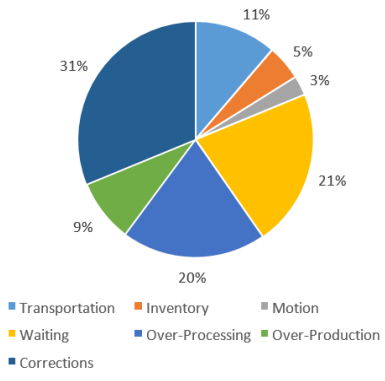

Fig. 1 Significant wastes in the industry

The pie-chart (Fig.1) clearly shows that the most significant type among the wastes considered is ***corrections***, followed by ***waiting*** which in turn is followed by ***over-processing***.

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A. *Corrections*

Primary reasons for corrections occurred in the design stage rather than the construction stage. Causes of corrections in the design stage were frequent revisions of drawings, slow response on doubts arising from the design, unavailability of drawings at the work site and errors in drawings/design. Lack of understanding between the client and the consultant, miscommunication between the civil engineer and the drafters and poor supervision and inspection were the driving forces that lead to rework in the design stage. Other prime causes of corrections were interference from other trades or other crew members, disputes with consultants/ owner causing stoppage of work, lack of experience of craftsmen and rework due to field errors committed by craftsmen.

III. WAITING

Waste of waiting is any idle time produced when two interdependent processes are not completely synchronised. A systematic addition of time wastes in various stages of a project finally ends up causing significant delay to the project. The leading cause of delay due to waiting was found to be Labour strikes and hartals called by political parties in Kerala. Another major contributor is climatic interferences. Construction work had to be stalled due to the untimely rains during the month of March. Also, the shortage of water in the summer months of May and June lead to a lot of delay in concrete works in Kerala. Other factors were due to interference from other traders or other crew members and also due to rework due to field errors committed by craftsmen.

IV. OVER-PROCESSING

This term generally refers to unnecessary steps in operations, such as reprocessing, double handling, added communication, and double checking which adds no value to the product. Over-processing is often inserted into a process as a result of dealing with defects, over production or excess inventory. It was found that lack of experience of craftsmen was one of the major factors of over processing in Kerala. It was often found that more workers than what was required were assigned to do a work which lead to further coordination problems. Also it was noticed that there was a lack of clear quality standards. Often times it is seen that the foreman makes his own suggestions which in some instances may contradict to what is actually required. Other leading factors include lack of periodic meetings with the site personnel, supervisors and civil engineers and also ineffective planning and scheduling of the project.

V. CASE STUDY: KOZHIKODE

Projects are conceptualized and implemented with the primary aim of completion in time. Delay to the project is a failure to implement project management principles. The aim of the case study approach is to evaluate a live and/or completed project which was undertaken in Kozhikode using Lean Construction principles and to gain insight into the feasibility of Lean principles in construction in Kerala.

For the case study, we have selected a premium 16 storey apartment buildinglocated at Puthiyangadi, Kozhikode. The Builders are known for implementing Lean principles into their design and construction which is why we chose one of their projects for our case study. It is an on-going project which commenced on November 2016 and is scheduled to be completed by August 2019. It consists of 65 apartments of 1BHK, 2BHK, 3BHK and 5BHK type. The 1st phase consists of 3 blocks and 2nd phase consists of 2 blocks.

Other works include the swimming pool, parking area and landscaping works.

A. Major constraints of their work schedule

1. An initial six month delay in obtaining building permit. Construction commenced only on the seventh month.
2. The supply of power for the project including Testing & Commissioning.
3. Any changes required by the client/customer affecting the completion.

B. Major success factors

1. The major success factor is the commitment from the client to ensure that the project completes on time.
2. A biweekly meeting attended by the M.D, Principal Architect and the managing civil engineers is conducted to ensure the smooth running of the building project.
3. Periodic meeting with all eleven contractors to discuss and mitigate any issue that arises during the construction process.
4. All Drawings and Documents are prepared six months prior to the commencement of building construction and these are checked for shortcomings, if any, using appropriate software.
5. As the construction progresses, these shortcomings are again put through a second round of inspection so as to eliminate every and all sources of undue and unfortunate errors.
6. Utmost care is taken to ensure that there is no cost overrun. If the client has specific preferences that cost more, measures are taken to reduce the costs elsewhere ensuring that there is no net cost overrun.

A salient feature of the questionnaire filled byEstimation Manger of Builders was that most of his specific root causes of delays were rated at the ranges of 1 and 2 (least causes) ONLY. This attests to how far a company like Crescent already incorporates lean principles in their day to day workings, ensuring optimum client satisfaction and minimisation of wastes.

C. Delay Mitigation Measures

- Frequent progress meetings
- Use up-to-date technology utilization
- Use proper and modern construction equipment
- Use appropriate construction methods
- Effective strategic planning
- Commitment to projects
- Proper material procurement
- Accurate initial cost estimates
- Clear information and communication channels
- Acceleration of site activities
- Frequent coordination between the parties involved
- Proper emphasis on past experience
- Proper project planning and scheduling
- Complete and proper design at the right time
- Proper site management and supervision
- Collaborative working in construction
- Compressing construction durations
- Ensure timely delivery of materials
- Systematic control mechanism

VI. CONCLUSIONS

Our study focused on looking at the key wastes in the industry and we were able to satisfactorily come to the conclusion that *frequent revisions due to drawing errors/reworks* was one of the primary causes of delay, with a good sample size to back the result. Wastes due to *Correction, Waiting and Over Processing* are something that most of the companies we considered faced, and it is high time we look into practical ways of mitigating most, if not all of these wastes. We believe we have drawn out a few solutions to tackle the same, taking inspiration from some companies that presently follows Lean principles in practice. While the findings are by no means exhaustive nor conclusive owing to the inherent flaws in a survey system of limited sample sizes, this project may be considered as an effort to see the issues the current industry faces in all levels of the hierarchical tree. All things considered, we believe we were even able to impart a portion of the knowledge we gained from our studies to various individuals involved in the industry, the end objective always focused on seeing how we can improve the construction scenario in the State. Further research and expansion of the existing survey will go a long way towards pinpointing the core issues the industry faces on a long term basis. As Walter Gilbert rightly put it, “why do we do basic research? To learn about ourselves of course”.

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